AD-A186 268 COMPUTATIONAL SUPPORT FOR DIVERSE RESEARCH PROJECTS(U) 1/1
COLORADO UNIV AT BOULDER D R KASSOY 06 JUN 86
AFOSR-TR-87-1226 AFOSR-85-0090

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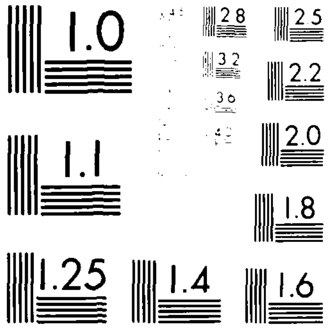

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REPORT DOCUMENTATION PAGE

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19 ABSTRACT (Continue on reverse if necessary and identify by block number)

A description is given of computer and peripheral equipment purchased. Specific items and prices are included. Brief summaries of six research projects that have benefitted from extensive use of the purchased computer system are given.

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Example: *The subject "Solid Rocket Motors" is Field 21, Group 08, Subgroup 2 (page 32, AD-624 000).*

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AFOSR-TR- 87-1226

FINAL REPORT

To The

AIR FORCE OFFICE OF SCIENTIFIC RESEARCH

Concerning

Computational Support For
Diverse Research Projects
(Grant #AFOSR-85-0090)

D. R. Kassoy, Principal Investigator
University of Colorado, Boulder 80303

June 6, 1986

1. Introduction

In December 1983, a proposal for "Computational Support for Diverse Research Projects Supported by DoD" was submitted to the DoD Instrumentation Program. A grant, AFOSR-85-0090, was awarded to the University of Colorado, Boulder with a support figure of $155,085. This amount included $120,000 from AFOSR and $35,085 from the University of Colorado matching funds.

2. Equipment Purchased

During the grant period, January 1, 1985 - December 31, 1985, the following equipment purchases were made:

1.	Pyramid 90X computer system Including: a) 6MB Error Correcting Memory b) 16 User Operating System c) ANSI Fortran and EMACS Screen Editor d) Multibus Adaptor e) Ethernet Controller f) 9-Track Magnetic Tape Drive g) Floating Point Unit With Data Cache h) 450MB Winchester Disk i) Miscellaneous Software	$106,280.00
2.	Shipping Charge for Item #1	707.60
3.	Fujitsu Eagle 410D/450MB Winchester Drive	7,995.00
4.	Transeiver - Micom Interlan	456.00
5.	Matrix Printer - CI-3500, CITOH Electronics	1,150.00
6.	(4) Graphics/Terminals - CI-414A, CITOH Electronics	4,105.00
7.	(4) Terminals - Zenith Z-29A	1,917.60
8.	(2) IBM P.C. Systems (Smart Terminals) Including Epson FX-185 Printers	4,585.50
9.	(4) Hayes Modems	620.00
10.	NAG Software Manuals	225.00
11.	Hardware, Wires and Cables	53.38
12.	Manual Covers and Binders	130.27
	Total	$128,195.37

Minor alterations in the equipment list described in the Grant Amendment dated March 1985, have been made as a result of alterations in computer system technology and price structure. The equipment purchased facilitates the goals of the proposed program.

During the period of the AFOSR grant, a large amount of computer-related equipment became available to the College of Engineering through industrial donations and outright purchases. In addition, significant changes in technology occurred between the submission of the last budget revision in February 1985 and the present date. These factors led me to conclude that certain originally-planned purchases did not represent effective use of scarce resources. After purchase of the primary system with expenditures of $128,195, I determined that the matching funds would remain available for future use and thus delayed additional purchases. This pause gave me an opportunity to determine which additional equipment would enhance the effectiveness of our Pyramid system.

The following plan is submitted for expenditure of the remaining University of Colorado matching funds:

Imagen Laser Printer (1)	$ 8,225.00
CITOH Matrix Printer (Graphics Capability) (2)	7,750.00
Smart Terminal Systems (IBM PC with Peripherals) (2)	6,250.00
Software	1,664.00
Facility Modification Costs	3,000.00
Total	$26,889.00

These purchases will be made during the next several months. A report of activity will be provided upon completion. A letter outlining these plans and submitted with the University of Colorado Financial Report to AFOSR appears in Appendix I.

3. Research Programs Utilizing the Pyramid System

(a)(i) "A Fundamental Mathematical Theory For The Dynamics of Combustion Processes", ARO Mathematical Sciences DAAG 29-85-0209. J. Bebernes and D. R. Kassoy.

(ii) "Thermal Explosions In A Confined Reactive Gas Mixture", National Science Foundation INT 8302371, D. R. Kassoy.

Combustion processes occurring in compressible gases generate significant gasdynamical phenomena including acoustic waves as well as weak and strong shock waves. The mathematical models used to describe these events exhibit both reaction-diffusion and hyperbolic characteristics. Asymptotic methods, based on several small parameters, provide a useful tool for developing solutions which resolve physical processes on widely disparate time and length scales. Beforehand knowledge of these scales can be used profitably to generate numerical schemes capable of describing the complex thermomechanical processes occurring in compressible reactive systems. The Pyramid System has been employed to develop and run an implicit code based on the one-dimensional, unsteady reactive Navier-Stokes equation. Results obtained describe the birth of strong shock waves in an inert gas following high levels of power deposition at a planar boundary and the initiation and evolution of a planar detonation wave in a reactive gas. Related computations are envisioned for a spherical geometry and for modelling reactive gas-dynamics in a piston-cylinder configuration.

(b) "Unsteady Separated Flows: Structures and Processes," AFOSR Grant 81-0037 (Extended to May, 1987), M. Luttges and C. Y. Chow.

The Pyramid computer is being used to carry out a research project on numerical simulation of streaklines traced by smoke particles injected upstream of an airfoil performing various unsteady motions, including pitching and oscillating motions. A comparison of the computed results with pictures taken in the laboratory will facilitate the interpretation of many interesting features shown in the unsteady flow smoke photographs.

(c) "Chemical Kinetics of Nitramine Propellant Combustion," AFOSR Grant 84-0006, M. C. Branch.

The combustion of nitramine based solid rocket propellants includes solid decomposition reactions and gaseous reactions near the propellant surface. The gaseous reactions differ from flames in air because they are supported by NO_2 or NO as an oxidizer and they may have multiple luminous zones. Earlier studies of several fuel/NO_2 and fuel/NO flames have been reported in the literature which also have multiple luminous zones. No detailed chemical kinetic mechanism was postulated or evaluated for the process so that the basic chemistry controlling the flame structure remains uncertain.

We are conducting low pressure flame studies of $CH_4/NO_2/O_2$ and $CH_2O/NO_2/O_2$ mixtures which identify reactant, intermediate, and product species profiles through the flame. The comparison of these measurements to a flame model including kinetics is used to evaluate the quantitative accuracy of the kinetic mechanism. Flame reactions are followed experimentally by precise, spatially resolved measurements of species concentration and temperature profiles above a low pressure, one dimensional, laminar flat flame burner.

Stable species concentrations are measured with quenching quartz sampling probes followed by gas chromatographic and chemiluminescent gas analysis. The intermediate species CN and CH and temperature were measured by linear laser induced fluorescence and laser absorption. The experimental arrangement for laser absorption and laser induced fluorescence measurements uses a Lambda Physik EMG 52 MSC Excimer Laser to pump a Lambda Physik FL2001 Dye Laser. The excimer laser pulses at 0.1 to 100 Hz and has a pulse energy of 50 mJ at 308 nm. The Lambda Physik FL2001 Dye laser has a wavelength range of 320 to 970 mn and a bandwidth of 0.22 cm^{-1} at 580 nm. Typical pulse energies are 10 jto 15 mJ and pulsewidth is 5 to 20 nsec with background of less than 1%.

The laser light output from the dye laser is filtered and a beam splitter used to divert part of the beam to a power meter monitor. Light then passes through the burner pressure vessel and is focused through the flame. Separate focusing arrangements and mirrors are used for the laser absorption and laser fluorescence measurements. The collected light from fluorescence or the attenuated light from absorption is then focused onto a photomultiplier tube and is processed by a signal averager and recorded. A Hewlett-Packard 9816S computer is available for controlling the spectrometer scan and other experimental variables and analysis of data from the experiments.

The pyramid computer has been used for data reduction from the flame structure measurements and in chemical kinetic modeling of the flame reactions. The chemical kinetic modeling requires the numerical integration of the reaction mechanism which consists of approximately 50 to 100 reactions involving 15 species which are known to be important in the reaction process. The numerical integration is accomplished with a Fortran computer program for steady state, burner stabilized, premixed, laminar flames. The program includes the effects of finite rate chemical kinetics and molecular transport phenomena. The governing equations for the flame are represented by a finite difference approximation and a Newton method is used to solve the resulting boundary value problem.

The comparison of the measured species concentration profiles with the calculated profiles shows that the reaction of CH_4 and NO_2 has a distinct two zone structure. The rapid first stage reaction between CH_4 and NO_2 is primarily due to reactions of these species with H atoms. These reactions are also responsible for much of the heat release of combustion. These first stage reactions also keep the radical concentrations (H, OH, O) low so that second stage reactions are slow.

The primary reactions of the second stage are those reducing NO and oxidizing CO. These reactions are also exothermic and increase the gas temperature. This stage of the reaction does not begin, however, until the first stage reaction is complete and it is possible for the radicals to increase in concentration. The radical concentrations during this stage of the reaction are generally about an order of magnitude higher than in the first stage.

(d) "Diverse Computational Projects," P. D. Weidman.

The three projects outlined below have been implemented on the M.E. Pyramid since approximately January 1986.

The first project involves the numerical integration of a nonlinear partial differential equation describing radial wave propagation. The goal of this project is to determine a criterion for the transition from linear to nonlinear evolution of radially propagating free surface waves.

The second project is concerned with the numerical integration of functions defined by combinations of incomplete elliptic integrals and their derivatives. This problem has application to capillary-gravity wave propagation in narrow channels with fixed contact lines.

The last project involves the numerical solution of a transcendental eignevalue problem related to the stability of natural convection in fluid saturated porous media with sidewall heat transfer. This effort was initiated to determine the complex modes of fluid motion in boxes of finite width.

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